EFFICIENCY OF SLOW SAND FILTER IN PURIFYING OF TUBE WELL WATER IN KG. FAJAR, GAMBANG, KUANTAN

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ABSTRACT

Slow Sand Filter (SSF) can be effective for water purification. The purpose of purifying water is to increase the quality of water that is harmless and safe for human consumption. The formation of "*schmutzdecke*" can vary the efficiency of SSF. The tube well in the water distribution system in the study area. The untreated water from tube well was collected from Kg. Fajar, Gambang. Unfortunately, the main problem of tube the well water is the contamination by E. *coli* and heavy metal. Therefore, required filtration has been analyzed to increase the water quality and efficiency to remove of E. *coli* and reduce selected parameters. To solve this problem SSF with adding coconut fibers, bagasse and oil palm fibers were recommended to treat the tube well water. The guideline values of water quality was based on National Drinking Water Quality Standard Malaysia (NDWQS). The percentage removal of heavy metal in water were also analyzed perfectly. SSF with adding coconut fibers, bagasse and oil palm fibers has been shown to be effective for the removal of E. *coli* and reducing selected parameters. From the study results, the removal of physical parameters was up to 93%, while for chemical parameters up to 73%. Hence, SSF can be used for removal of E. *coli* and heavy metal in the study area.

ABSTRAK

Slow Sand Filter (SSF) sangat berkesan untuk pembersihan air. Tujuan pembersihan air adalah untuk meningkatkan kualiti air yang tidak berbahaya dan selamat untuk kegunaan manusia. Pembentukan "Schmutzdecke" boleh mengubah kecekapan SSF. Telaga adalah sistem pengagihan air di kawasan kajian. Air telaga yang tidak dirawat diambil dari Kg. Fajar, Gambang. Malangnya, masalah utama air telaga adalah pencemaran oleh E. *coli* dan bahan logam. Oleh itu, penapisan diperlukan telah dianalisis untuk meningkatkan kualiti air dan kecekapan untuk mengeluarkan E. *coli* dan mengurangkan parameter yang terpilih. Untuk menyelesaikan masalah ini, SSF dengan penambahan sabut kelapa, hampas tebu dan sabut kelapa sawit disyorkan untuk merawat air telaga. Nilai garis panduan kualiti air adalah berdasarkan dari piawaian kualiti air minum kebangsaan Malaysia (NDWQS). Peratusan penyingkiran bahan logam di dalam air juga dianalisis dengan sempurna. SSF dengan penambahan sabut kelapa, hampas tebu dan sabut kelapa sawit telah terbukti berkesan untuk penyingkiran E. *coli* dan mengurangkan parameter yang terpilih. Dari hasil kajian, penyingkiran parameter fizikal meningkat kepada 93%, manakala bagi parameter kimia sehingga 73%. Oleh itu, SSF boleh digunakan untuk penyingkiran E.*coli* dan bahan logam di kawasan kajian

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LIST OF SYMBOLS & ABBREVIATIONS

BOD	Biological Oxygen Demand
E-*coli*	Escherichia Coli
mg/L	milligram per litre
NDWQS	National Drinking Water Quality Standard
NTU	unit for turbidity
pH	measure of the amount of free hydrogen ions concentration in water
SSF	Slow Sand Filter
TSS	Total Suspended Solid

CHAPTER 1

INTRODUCTION

1.0 Background of Study

Clean water is becoming scarce commodity in many populated area of the world. People still do not realize how's important to have clean and untreated water to be used. Untreated means not conserved, altered or upgraded by the use of a physical, chemical or biological agent. Whereas, untreated water is non-potable water that has been subjected to any process intended to eradicate infection of bacteria, viruses and parasites. These organisms common causes illnesses and infect any of the organs of the body. The enhancement number of human population in the world will cause the high demand of clean water. Unfortunately, sources of clean water have been contaminated by various human activities (Marion et al, 2011). Ordinarily, rural communities have high immunity body system and the body also prepared to facing with any virus or bacteria that attacks the body. Yet, it is not astute to take all risk for the whole life

All of the usable freshwater in the world, about 97% of it is groundwater. Groundwater system globally provides 25% to 40% of the world's drinking water (Brown, 2002). (The star, 2010) reported that the rate of groundwater consumption for Denmark (100%), Austria (98%), Thailand (80%), China (78%) and Malaysia (> 2%) that means, Malaysia need to explore the groundwater sources and not only depending on surface water sources.

Mostly, rural communities have their own water supply such as well without any treatment involved. Odour and turbidity are the main causes faced by the rural area communities. Thus, the water treatment is a method to purify the water from dangerous organism. The most effective with the low cost is slow sand filter. However, the knowledge about filtration mechanism still remains limited (Ellis 1 K., 1987). Filtration is one of the processes to ensure our clean water is safe from physically contamination. Filtration is the mechanical elimination of turbidity particles by passing the water through a porous medium. The purpose of filtration is to reduce all the turbidity particles carried over from the sedimentation phase, hence producing shimmering clear water with almost zero turbidity. Therefore, this study is to analyze the potential of slow sand filtration by adding natural material coconut fibers, bagasse and oil palm fibers as a medium to filter treated water as to characterize the water quality of tube well water and to determine the percent efficiency of slow sand filter to remove *E. coli* & to reduce selected parameter which is harmful for the rural communities.

1.1 Problem Statement

Lately, the fresh water supply quality become scarce due to the population growth rapidly and pressure on water resources. Besides, the phenomenon on water pollution is getting excessive contributing to scarcity water resources. The main sources of water supply though their water quality or quantity was increasingly at risk with pollution from various sources. (The star, 2008) reported about water shortage crisis looms over Malaysia. It is said that the country’s per capita renewable water was about 5,000 cubic metres. This problem was attributed to unsustainable management of water resources rather to the quality of water available.

Some of rural communities use a tube well sources to provide abundance of water. Nonetheless, mostly tube well users in Malaysia may experience the water quality problems. In 2008, 335 samples were taken from different well and it comes out with chagrin results. According the results it was found that iron, arsenic, manganese, phenol and total coliform recorded in the most of number of samples where exceeding the guidelines value.

Tube well water is an essential resource because we need water to drink. In my study area, tube well water becomes an option to people when they are having water crisis. Basically, tube well water is exposed to several of contamination. In some area, tube well water is close to surface that causes substances and particles easily to access to the water table. Substances are commonly used around house area such as paint, cleaning product, automotive fluid and yard product. It may harm well water quality and risk the well water contaminant. Thus, water filtration is the one of the method to improve water quality. Filters will work by physically removing infectious agents from water.

1.2 Objectives of Study

This study aimed to investigate the efficiency of slow sand filter in purifying of tube well water. This aims can be achieved with the following objectives:

i. To characterizes the water quality of tube well water in study area.

ii. To determine the percent efficiency of slow sand filter to remove *E. coli* & to reduce selected parameters.

1.3 Scope of Study

Slow sand filter only can support in a small area that are using tube well in their life. Therefore, this study more focuses on characteristic of water quality of tube well water sources. The tube well water samples will be collected from Kg. Fajar, Gambang, Pahang. The parameters for this study can be divided into physical and chemical parameters. Hence, the laboratory that will be conducted to increase the water quality of tube well water and to find out the percent efficiency of slow sand filter to remove *E. coli* & to reduce selected parameter.

1.4 Significant of Study

Base on this study, the slow sand filter will construct with several layer of fines, gravel, natural material and rocks to ensure the filtered water is safe to use and follow the Drinking Water Quality Standard Malaysia values. Therefore, there are several test need to be conducted to ensure the analysis of result before and after filtration show reduces selected parameter & to remove *E. coli* in water. At once, the effectiveness of slow sand and characteristic water quality of tube well water can be increased.

1.5 Expected Outcomes

This investigation is essential as it given the efficiency of using slow sand filter as a method of water treatment. This study can be improving the quality of tube well water and the most important is to ensure that the source of water is preserved and protected. Besides, the percent efficiency of slow sand filter to remove *E. coli* & to reduce selected parameter will determine. Thus, slow sand filter can be applied this is because it does not use chemical that will affect human's health. It is also vital for the future to promote proper waste treatment process with low cost of investment and it still the chosen method of purifying water supplies for some major cities of the world.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The main an upsurge human productivity and longevity is use good quality water (Urbansky, E.T, & Magnuson, M.L, 2002). The provision of good quality household drinking water is often considered as an important means of improving health (Moyo, S., Wright, J., Ndamba, J & Gundry, S. 2004). Water is a main component in determining the quality of our lives. Water is known as a natural solvent. Currently, people are concerned about quality of the water. Though water covers more than 70% of the earth, only 1% of the earth's water is available as a source of drinking. Unfortunately, groundwater expose in numerous different materials, including organic and inorganic matter, chemicals, and other contaminations. Thus, water needs to be treated. Water quality differs from sources to sources and quality requirement differs according to it usage.

2.1 Water Treatment

Water treatment is where the treated water is being purified to increase a quality of water for us to consume. With growth of technology, there are many method of water treatment used today. One of the methods is filtration. This method is extensively used technique in water treatment.

2.1.1 Filtration System

The purpose of filtration is to remove suspended particles from water by passing the water through a medium such as sand. As the water passes through the filter, floc and impurities get stuck in the sand and the clean water goes through. The filtered water collects in the clear well, where it is disinfected and then sent to the customers. Filtration is usually the final step in the solids removal process which began with coagulation and advanced through flocculation and sedimentation. In the filter, up to 99.5% of the suspended solids in the water can be removed, including minerals, floc, and microorganisms. Filtration is now required for most water treatment systems. Filters must reduce turbidity to less than 0.5 NTU in 95% of each month's measurements and the finished water turbidity must never exceed 5 NTU in any sample.

a) Mechanical straining

The voids of sand grains behave like a fine sieve. So when water is allowed to pass through the sand bed, the suspended particles are arrested by the voids and the clear water is allowed to flow towards the bottom. Passing the water through a filter in which the pores are smaller than the particles to be removed.

b) Sedimentation

The voids of sand grains act like small sedimentation tanks. The fine suspended particles are arrested in these tanks by the gelatinous film developed during the process of filtration.

c) Adsorption

In many cases of most important mechanism of filtration. Adsorption is the gathering of gas, liquid, or dissolved solids onto the surface of another material.

2.2 Types of Filtration Methods

2.2.1 Pressure Filter

Pressure filters consist of closed vessel containing beds of sand or of other granular material through which water is forced under pressure. These filters are frequently used in certain industrial situation. And a number have been installed for public water supplies. They are especially suitable in plants where a high degree of automation is necessary, in remotely situated treatment plants that have to operate with only occasional attendance, and in systems where for some reason it is desirable to have only a single pumping stage between the inlet and distribution system. As their initial cost may be high, especially when their component parts have to be imported, their principal use is in the industrialized countries where they are manufactured.

2.2.2 Gravity Filter

A gravity filter consists essentially of an open-topped box, drained at the bottom, and partly filled with a filtering medium. Treated water is admitted to the space above the sand, and flows downward under the action of gravity. In turn, gravity filter are subdivided into slow and rapid types, the latter operating at rates 20-50 times faster than those of the former, and hence requiring only some 2-5% of the area needed for slow filter (MacPhee, 2001). In practice the reduction in space requirements is partially offset by the additional pretreatment stages needed for rapid filtration.

Both types of gravity filter are equally efficient in removing suspended matter, it would appear that the rapid filter must become chocked and require cleaning 20-50 times as often as the slow. (MacPhee, 2001).

2.3 Slow Sand Filter (SSF)

The oldest water treatment system in known as slow sand filtration. Slow sand filtration is a simple technology used for pathogen and particle removal in drinking water purification (Langenbach et al., 2009). Slow sand filter is an efficient method of removing particulate suspended matter and is therefore applicable to the treatment of tube well water containing solids in suspension. The physical, chemical and biological means of removing bacteria and suspended particles in treated water can be done using slow sand filter (Bauer et al., 2011; Langenbach et al., 2009). Its principal use, however, is in the removal of organic matter and pathogenic organisms not normally found in tube well water, for which purpose it is a particularly appropriate from of treatment for surface waters of moderate turbidity. Certain conditions may be encountered that may offset the advantages of slow sand filtration and lead to the choice of rapid filters as a more appropriate treatment method.

The use of slow sand filter to remove bacteria from contaminated tube well water has been an attractive option as a filter system in both developed and developing countries especially in rural communities due to its low cost, ease of operation and minimal maintenance requirements (Nassar & Hajjaj, 2013; Logsdon et al., 2002).

2.3.1 Basic Components of Slow Sand Filter

Basically, a slow sand filter unit consists of a concrete tanks (of area > 1000m^2 in water treatment works, but smaller in rural scale application) containing a supernatant treated water layer, a bed of filter medium, a system of under chains and a set of filter regulation and control devices.

2.3.2 Bed of Filter Medium

Slow sand filter a complex merger of biochemical, biological and physical processes. The slow sand filter will be functioning effectively when maintaining a proper operated and maintenance. No chemicals are added to aid the filtration processes.

The bed of filter at bottom layer is rocks which are consisted to 50 mm of height (Marion et al., 2011). The range size are available is 4.75 to 12.0 mm diameter. Followed by gravel layer which also cover for 50 mm height. Then, the suggested range size is 1.18 mm to 4.75 mm diameter. The two fine sand layers will be consisted to 300 mm in height. Sand is characterized by the diameter of the individual sand grains (0.15-0.35 mm). Besides, the requirement of the type of sand appropriate to use are hard, angular grains free from loam, durable, clay, and organic matter (Lee, 2001). Angular grains will decrease the porosity and increase resistance to flowing water, (Lee, 2011). Coconut fibers, bagasse and oil palm fibers will be placed in the middle of fine sand and sand.

This design provide in rural area. If the area a large, it necessities to change the design of the filter which prefers the Rapid Sand Filter (RSF). RSF valid to the urban area. The water supply must be consistent continues. This is because, the SSF will affect to the water quality standard.

2.4 Development of Slow Sand Filter

SSF are very effective for tube well water sources. The filter had been modified by adding coconut fibers, bagasse and oil palm fibers layers. The function of this added layer to enhance the beneficial bacteria medium growth. Therefore, the water quality and percent efficiency of slow sand filter to remove *E. coli* & to reduce selected parameters could be increase. The physical characteristics of coconut fibers, bagasse and oil palm fibers allow the bacteria growth naturally. As like top fine sand, the coconut fibers, bagasse and oil palm fibers medium will play same roles to filter. It is environmental friendly design in such a manner to provide a safe drinking water for people. All components materials are natural and associated with the biological process.

2.5 Development of Schmuztdecke

In the top few millimeters of the layer, slow sand filter work through the formation of an algae layer called Schmutsdecke. The Schmutsdecke is formed in the first 7 to 20 days of operation and consist of bacteria, fungi, and many more.

During the filtration process occurs, the green layer at the sand will be growing and become mature. In slow sand filtration, water percolates slowly thorough a porous sand bed allowing the production of potable water by a combination of physical-chemical and biological particulate removal mechanism. This is the unique features of this filter, which contained schmutdecke. Formation of *schmutzdecke* on the surface of the sand bed as filtration progresses is considered as the important process of purification mechanism of slow sand filters. Protozoa, bacteria, algae and other forms of life within the filter bed contribute to pollutant removal (Banda, 2011; Bonnefoy, 2002) including *E. coli* (Mwabi et al., 2013). Therefore, slow sand filter are taking time due to get a completely filter functioning.

2.6 National Drinking Water Quality Standard

National primary drinking water regulations was established by Minister of Health Malaysia which set water quality standards for drinking water contaminants. The drinking water quality standard are applicable to all public water supply system, tank supplies and water used for bottled drinks and ice manufacturing.

2.7 Characteristic of SSF Analysis

2.7.1 Physical Impurities

2.7.1.1 Turbidity

Turbidity refers to the cloudiness of water. It can be a problem in surface water sources. The material causing the cloudiness can be inorganic such as clays, silts or sand or organic such as algae and leaf particles. Turbidity means the measurement of lack of water clarity that is measured in NTU. Turbidity is the result gained from suspended solids in the water that causes from clay, silt, and plankton to industrial wastes and sewage.

The clearer the water is, the lower the turbidity. High turbidity may be caused by soil erosion, waste discharge, urban runoff, flooding, increased flow rates, algae growth and many other aspects. Suspended solids reduce the amount of light that can pass through the water. As less light penetrates the water, photosynthesis slows, releasing less oxygen into the water. If light is blocked to bottom-dwelling plants, they will cease to produce oxygen and will eventually die. As they decompose, bacteria will use more oxygen from the water. This will decrease the amount of dissolved oxygen concentration in the water and may cause stress or even death to aquatic organisms that need high amount of oxygen to survive.

2.7.1.2 Total Suspended Solid (TSS)

The term “sediment” and “silt” are often used to refer suspended solids. Sediments when the suspended particles settle to the bottom of a water body. Suspended solids consist of an inorganic fraction (silt, clays, etc.) and an organic fraction (algae, bacteria and detritus) that are carried along by water as it runs off the land. The inorganic portion is usually considerably higher that the organic. Both contribute to cloudiness of water. Water with high sediment loads is very obvious because of their “muddy” appearance. Sediment is usually measured as a concentration of total suspended solid, which is the dry weight after filtering a water sample that is expressed in mg/L.

2.7.2 Chemical Impurities

2.7.2.1 Biological Oxygen Demand (BOD)

BOD is the quantity of oxygen utilized by a mixed population of micro-organisms to biologically degrade the organic matter in the wastewater under aerobic condition. It is used as a measure of organic pollution as a basis for estimating the oxygen needed for biological processes, and as indicator of process performance. It is the most important parameter in water pollution control. BOD indicates the presence of biodegradable organic matter quantitatively which consumes dissolved oxygen from water.

2.7.2.2 pH

pH is a measure of the amount of free hydrogen ions concentration in water. pH is measured on a scale ranging from 0 to 14 with seven considered neutral. At a pH below 7, the water is acidic at a pH above 7, the water alkaline. The lower the pH showed, the acidity grows greater, the higher the pH, the greater the alkalinity. The pH of water affects the solubility of many toxic and nutritive chemicals and therefore, the availability of these substances to aquatic organisms is affected. As acidity increase, most metals become more water soluble and more acidic. Alkalinity is the capacity to neutralize acids, and the alkalinity of natural water is derived principally from the salts of weak acids.

2.7.2.3 Escherichia Coli *(E.Coli)*

E. coli is present in large number in the intestinal flora of human and animals, where it generally causes no harm. However, in other parts of the body, *E. coli* can cause serious disease, such as urinary tract infection, bacteremia and meningitis. *E. coli* is a dangerous bacterium that can cause gastrointestinal illness and even death in human, *E. coli* is a bacterium that is naturally found in the guts of ruminant animals such as cattle. Rural water system are the most susceptible to *E. coli* contamination, *E. coli* in the feces of animals can be transported by water and may end up in water well that may act as a primary water supply for many people. The presence of any *E. coli* in a water sample cause for intermediate concern. The presence of any *E. coli* makes water completely unsafe to consume

2.7.2.4 Heavy Metals

2.7.2.4.1Iron (Fe)

Iron is an essential mineral and an important component of protein involved in oxygen transport and metabolism (Ju Yung Lee). The concentration of iron in natural waters is frequently limited by the solubility of its carbonate. Water of high alkalinity often, therefore, have lower iron content than water of low alkalinity. The element iron is the most useful and abundant of the heavier metals, being present in nearly all rocks, soils, animals, and plant ashes, but seldom in the pure state.

Iron is one of the most troublesome elements in water supplies. Making up at least 5% of the earth’s crust, iron is one of the earth’s most plentiful resources. Rainwater as it infiltrates the soil and underlying geologic formations dissolves iron. Although present in drinking water, iron is seldom found at concentration greater than 10 milligrams per liter (mg/L) or 10 parts per million. However, as little as 0.3 mg/l can cause water to turn a reddish brown color.

Iron is mainly present in water in two forms; either the soluble ferrous iron or the insoluble ferric iron. Water containing ferrous iron is clear and colorless because the iron is completely dissolved. When exposed to air in the pressure tank or atmosphere, the water turns cloudy and a reddish brown substance begins to form. The sediment is the oxidized or ferric form of iron that will not dissolve in water and iron is not hazardous to health yet it is considered a secondary or aesthetic contaminant. It is essential for good health, iron helps transport oxygen in the blood. Concentration of iron as low as 0.3 mg/l will leave reddish brown stains on fixtures, tableware and laundry that is very hard to remove.

2.7.2.4.2Copper (Cu)

Copper is a metal found natural deposits such as ores containing other elements. Copper is widely used in household plumbing materials. The MCLG for copper has been set at 1.3 parts per million (ppm) because EPA believes this level of protection would not cause any of the potential health problem.

Since copper contamination generally occurs from corrosion of household copper pipes, it cannot be directly detected or removed by the water system. Instead, EPA is requiring water systems to control the corrosiveness of their water if the level of copper at home taps exceeds an Action Level.

The Action Level for cooper has been also set at 1.3 ppm because EPA believes, given present technology and resources, this is the lowest level to which water systems can reasonable be required to control this contamination should it occur in drinking water at their customers home taps.

Copper is an essential nutrient required by the body in very small amounts. However, EPA has found copper to potentially cause the following health effects when people are exposed to it at levels above the Action Level. Short periods of exposure can cause gastrointestinal disturbance, including nausea and vomiting. Use of water that exceeds the Action Level over many years could cause liver or kidney damage. People